

Imaging Systems for the Creation of a Large Digital Image Archive

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Abstract

Creating a large digital image archive poses a number of challenges with regards to image capture and image processing. Different types and conditions of originals require different scanning approaches. High quality digital capture and processing still needs human intervention, making high productivity while maintaining high quality a difficult task to achieve. Archiving images in digital form also includes the assumption that they will be retrieved at an unknown date without the presence of the original and viewed on output devices with unknown characteristics. To ensure that any future display matches the original photographic intent, digital image data has to be stored and characterized in a standardized, non-interpretive way. The paper will describe imaging strategies employed at Corbis Corporation, a company with a large image archive containing approximately a million digital images. It will also discuss areas of improvement necessary for fully automated image capture and processing relevant for building digital image archives.

Introduction

Building a digital image archive for commercial use encompasses all areas of imaging technology: scanning, image processing, compression, image archiving, and image delivery. The term "archive" implies that all digitized images are not only optimized for current work flows and imaging devices, but maintain usability on future, as yet unknown delivery and output systems. Any production decisions based on currently available technology have to be made with consideration to future image uses and markets.

In the case of a commercial digital archive, the digital image is the *product* as opposed to the image illustrating a product. Customers are making buying decisions by viewing the images either on screen or on hard copy output, and very often both. This implies that the images have to look perfect on any given output, with little or no regard to the original artwork. In most cases, the customer never will have seen the original, or will only have a memory recollection of it.

Currently, Corbis has only limited control over the screen or output rendering of the images on the customer's side. When targeting a wide audience, computer platforms, color management systems, calibration procedures, color space conversions, or output devices cannot be mandated.

Archive Production

Rendering Intent of the Original Artwork

Original artwork cannot be all treated equally. Different digitizing approaches have to be established according to the type, condition and perceived value of the originals. Current scanning technology deals reasonably well with current film emulsions and formats, provided that they have been exposed and processed correctly. However, many collections of high artistic and/or historical value were captured on photographic material that not only isn't available anymore, but has also deteriorated to some degree.

At Corbis, there are several rendering intents that apply while digitizing original artwork, with the second being the most common:

The Photographic Image is Rendered

In this case, the images are scanned with the intent to match the appearance of the original photographic image. The quality of the digital image can be evaluated by visually comparing the original to a reproduction on a calibrated display device with a similar contrast range. The assumption is made that the original photograph has been exposed and processed perfectly.

The Photographer's Intent is Rendered

There are many photographs with high content value that were not exposed or processed correctly. They can be color casted, over- or underexposed, or can have the wrong contrast. In these cases, the photographer's *intent*, instead of the original photograph, needs to be rendered to achieve a pleasing reproduction. The scanner operator has to make decisions about tone and color reproduction by viewing the digitized image on a calibrated output device. This manual intervention determines the quality of the reproduction. Quality becomes highly dependent on the skill and experience of the operator.

The Original Appearance of the Photograph is Rendered

Often, older color photographs are faded and do not have sufficient visual color information anymore to make accurate

judgments about the original. Reconstructing these photographs requires special scanning and processing techniques.

The Original Scene is Rendered

When photographic reproductions of original art work are scanned, the original scene has to be rendered and the film characteristics have to be subtracted.

Scanning

With current scanning and color management technology, only the first case can be automated if it is possible to match the dynamic range of the output to the original. All other cases need manual intervention, either in the initial scanning process or in subsequent image processing. At Corbis, approximately 90 percent of all images need manual tone and color reproduction editing to achieve the desired result. Manual intervention is time consuming and requires highly skilled operators. As a result, production costs remain high for high quality, visually pleasing digital images.

Better automated image processing tools need to be developed to analyze raw sensor data and translate them to pictorially pleasing digital reproductions on defined output devices. Such tools would not only benefit Corbis, but future consumer scanning markets.

Image Editing

Operator judgments made in terms of color and contrast cannot be reversed in a 24-bit RGB color system. Any output mapping different from the archived image's color space and gamma must be considered. However, archiving raw scanner data in higher bit-depth with no rendering intent defeats the purpose of the showing the customer a pleasing image.

As an option, a transformation could be associated with the raw scanner data. However, there is currently no software available that allows one to define the rendering intent of the image in the scanner "profile." Rendering intent is usually set during output mapping by the user, which would be the image buying customer in Corbis' case. If s/he chooses the wrong intent, the image would not reproduce optimally and a purchase might be jeopardized.

There is software available that allows the user to modify the scanner profile for individual images, and therefore to create "image profiles." That process is as work intensive as regular image editing in the scanner or image processing software. It also assumes that the input profiles can and will be read by the operating system and application the image is used in, not just by current but also future systems.

Archiving for each image a raw sensor data file in high bit-depth and a calibrated RGB 24-bit file at high resolution is not an option, considering the number of digital images the Corbis archive contains and the cost for storage systems and media.

Corbis is currently archiving images in a calibrated 24-bit scanner RGB color space. Low resolution preview images are corrected for monitor viewing. The viewing color space is defined as Sony Trinitron phosphors, a gamma of 1.8 and low room illumination. These viewing conditions are based on the default display of the Macintosh platform, which still drives most professional scanning equipment and is used by many professional image buyers.

Standard Color Space and Higher Bit-Depth

Optimally, Corbis would prefer to archive images in a calibrated 10-bit to 12-bit per channel standardized RGB color space. Having to communicate only one color space (or profile) to the customer's color management system would facilitate optimal rendering of all images across all platforms and devices. If the color space is standardized and universally recognized, it would eliminate the need to embed a profile into each image file. Embedding profiles into each image file creates too much of an overhead when delivering preview files over the Internet. There would also only be one "profile" that needs to be up-dated when color management specifications evolve in the future.

The sRGB color space proposed by Hewlett-Packard and Microsoft is a viable color space for most of Corbis' images. It is sufficiently large to accommodate most photographic reproduction intents. Additionally, images in sRGB will display reasonably well even on uncalibrated monitors.

Higher bit-depth per channel would allow Corbis to communicate the pre-defined rendering intent for each image, while leaving enough bit-depth for customers to modify the image and to map to the intended output device. It would also give a safety factor to the archive file if future high quality output devices require extensive mapping to as yet unknown color gamut and gamma. Also, colors that currently fall out of gamut could still be accounted for by leaving enough room on both ends of the value scale when defining black and white values.

For Corbis to realize such a system, devices that output image files in 10-bit to 12-bit sRGB color space have to be built. Additionally, a standard way to deal with higher than 8-bit per channel image data across platforms and applications has to be developed. Using a company specific proprietary file format is not an option; it is too vendor specific, does not ensure future compatibility with internal and external imaging systems and will inhibit automated delivery of high resolution files to the customer.

Image Delivery

Preview Images and Archive Images

Corbis has a web based search tool that allows internal and external customers to search the archive. The search results are first displayed as thumbnails of 128 × 128 pixels, two more preview options are available at 256 × 256 and 640 by 480 pixels, respectively. The images are JPEG compressed. Depending on the customer's system and/or bandwidth, Corbis currently delivers these preview images on-

line or on CDs. To protect intellectual property, the 640 by 480 preview images are encrypted and require that a Corbis viewer is down-loaded when viewing them over the web.

Professional customers can use the 640 × 480 pixel preview images for composites and page layout. For most applications, clients request the archived high resolution file for the final product. As the original image processing work done on the preview files, such as cropping, rotation, dust and scratch removal, color and tone corrections cannot be automatically translated to the high resolution archive file, some image editing needs to be applied to them. The delivery of high resolution files is therefore not automatic.

Ideally, the compressed preview file would also function as a proxy file that could be automatically replaced with the uncompressed, high resolution archive file in the customer's software application. Any additional image processing done by the customer on the preview files would automatically be applied to the high resolution file. That would require that the on-line preview images stored on a server and the high resolution archive images stored on tape are not only linked, but have identical image properties that would make automatic replacement seamless.

FlashPix™

Corbis is currently evaluating the use of FlashPix as its archive and delivery file format. There are many benefits to FlashPix that make it a viable format for a commercial digital image archive. Besides its multi-resolution structure with no spatial limits, support for standard color spaces sRGB and Photo YCC, and user definable JPEG compression by resolution and tiles, the following features are very useful:

Viewing Parameters

The format allows the definition of viewing parameters, such as crop, rotation, brightness, contrast and sharpen within the file without modifying the original pixels. The image can be adjusted for optimal output on a defined output device without changing the original scan data. Consequently, a user could import a compressed, low resolution FlashPix file into his/her application and further modify it. When desired, preview images could automatically be replaced with a high resolution archive file. All image editing by Corbis and by the customer would be applied during the final rendering of the image.

Storage of Non-Image Data

Non-image data such as file source, intellectual property, content description, scan information, etc. can be stored within a FlashPix file. Each Corbis image has extensive cataloguing information associated with it that could be displayed not only in the Corbis search tool, but also in other applications that support FlashPix. Additionally, the inclusion of rights management data into the image file is very important to a commercial digital archive where images are the product and have to be protected. Wide distribution of image files has always been limited because of the difficulty to ensure that the intellectual property of the creator is not violated. With FlashPix, static rights data such as author and provenance could now be included within the file, while dynamic data could be up-loaded by providing contact information or an electronic link to the creator.

There are some features that still need to be included into the file format specifications to make it a viable format not just for consumers, but also for professionals:

- Support for lossless compression
- Support for higher bit-depth per channel
- Support for more than three color channels (CMYK, multi-channel images)
- Support for color look-up tables and transformations
- Support for user definable viewing parameter processing filters
- Support for multiple images/layers within the same file (Examples: credit line, watermarking, cloning)

An Internet Imaging Protocol (IIP) has been developed by Hewlett-Packard, Live Picture and Eastman Kodak that specifies a command set with which a client application (plug-in, Java applet) can request data from a web server. In case of FlashPix files, the resolution and tiles down-loaded and displayed can be controlled from the client side. Consequently, Corbis could store one preview FlashPix file instead of multiple resolution JPEG files on its servers. The customer can control the down-load of the amount of information needed to make a purchasing decision.

Considering the wide-spread industry interest for FlashPix, one can soon expect to see support for the format across platforms, applications and devices.

Conclusions

It has been encouraging to see the development of high quality tools destined for digital image applications other than pre-press. However, there is still a need for more integrated systems to truly achieve a seamless, transparent work flow of images across platforms, devices and time. No imaging technology manufacturer will ever be able to solely dictate to the ultimate user, the consumer, which imaging system to use. Additional standards will have to be developed to facilitate communication between imaging systems and to enable high quality digital imaging, not just for commercial digital image archives, but also for consumers.

References

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The following web links lead to pertinent information:

sRGB: http://www.color.org/contrib/sRGB.html
FlashPix spec. : http://www.kodak.com/go/flashpix
Internet Imaging Protocol (IIP): http://image.hp.com
ICC specifications: http://www.color.org